and related approaches using sophisticated detection of fine ocular motion are in development. More direct systems based upon the detection of changing cortical electrical or blood-flow patterns may be predicted to be helpful in assuring return of some interaction with the intelligent world for these patients, but all such approaches will require the alert recognition of patients whose profound motor impairment causes an appearance of coma in the presence of a functioning but isolated mind.

GRANT E. GAUGER, MD

REFERENCES

Dumas A: The Count of Monte Cristo (1844). New York, Bantam edition, 1981, p 207

Gauger GE: Communication in the locked-in syndrome. Trans Am Soc Artif Intern Organs 1980; 26:527-529

Plum F, Posner JB: The Diagnosis of Stupor and Coma, 3rd Ed. Philadelphia, FA Davis, 1980

Laser Applications in Neurosurgery

THE USE OF LASERS (*l*ight *a*mplification by the *s*timulated *e*mission of *r*adiation) for neurosurgical procedures has gained increased acceptance over the past three years. Presently three laser sources are being used for neurosurgical procedures: the carbon dioxide (CO_2) laser; the argon (Ar) laser; and the neodymium-yttrium-aluminum-garnet (Nd:YAG) laser.

The major advantage of laser sources is gained when they are used with a micromanipulator (to reduce physiologic tremor) connected to the operating microscope. This allows increased precision, a very gentle removal of tissue with the absence of mechanical deformation and varying degrees of hemostasis depending on the specific laser source used.

Lasers are most useful when the following criteria are present: (1) firm, nonaspiratable tumor consistency; (2) the lesion is in a critical area or in the motor-speech area of the brain; (3) the lesion is moderately vascular, and (4) the approach is narrow and instruments partially obscure the operative field.

The CO_2 and Ar lasers have been used to greatest advantage in removing extra-axial tumors such as acoustic neuroma, meningioma and the like, especially those in critical areas. Adapted to stereotaxic frames, they have been used to remove deep-seated intra-axial lesions. Their use for intra- and extra-axial spinal lesions has been similiarly encouraging. The Nd:YAG laser has recently been used for removing moderately vascular tumors and vascular malformations. The recent development of an Nd:YAG micromanipulator will expand its applications to fine microsurgical procedures.

The Ar and CO_2 lasers have been used for neuroablative surgical procedures (such as those for dorsal root entry zone lesions, myelotomy, trigeminal tractotomy) and have decreased surgical morbidity. When the Ar laser is used to pump (stimulate) a dye laser, the red light produced has been used to activate a hematoporphyrin derivative to treat malignant neoplasms. The application of this therapy to brain tumors is under investigation at a few institutions such as the University of California at San Francisco, the Mayo Clinic and the University of Southern California.

Low-power, dedicated CO_2 lasers have been used to weld tissues—that is, to do microvascular and microneural anastomoses and tendon repair. Similar accomplishments have been achieved using the Ar and Nd:YAG lasers. Their clinical usefulness is under investigation.

Most recently lasers have been combined with fiberoptic endoscopes and angiographic catheters for vaporizing atherosclerosis in coronary and peripheral arterial vessels. The application of this new technology to cerebral vessels will be investigated in the near future.

In the next year, we will undoubtedly see new wavelengths introduced, each with its own specific application. Multilaser systems and the linking of lasers to computers for automated tissue removal, ultrasound depth-controlled lasers and new forms of delivery systems are potential advances. All of these innovations will increase the usefulness of lasers and improve our microneurosurgical techniques. Although the laser represents a technologic advance for neurosurgery, one must always keep in mind the adage "If you don't need a laser, don't use one."

MICHAEL S. B. EDWARDS, MD
JAMES E. BOGGAN, MD

REFERENCES

Boggan JE, Edwards MSB, Davis RL, et al: Comparison of the brain tissue response in rats to injury by argon and carbon dioxide lasers. Neurosurgery 1982 Nov; 11:609-616

Edwards MSB, Boggan JE, Fuller TA: The laser in neurological surgery. J Neurosurg 1983 Oct; 59:555-566

Robertson JH, Clark WC, Robertson JT, et al: Use of the carbon dioxide laser for acoustic tumor surgery. Neurosurgery 1983 Mar; 12: 286-290

Spinal Infusion of Morphine for Pain

IT IS NOW FIVE YEARS since the first report appeared indicating that prolonged analgesia followed intrathecal morphine installation in cancer patients. This report was quickly followed by others relating the experience of analgesia with the epidural use of morphine and meperidine. These initial trials were based on earlier research—which has been reviewed—showing the action of spinal opiates at certain sites within the nervous system. The number of articles describing intraspinal narcotic use has rapidly expanded since these initial reports.

Postoperative pain has been treated with promising results; excellent and long-lasting relief of pain is provided and there is a concomitant reduction in the need for additional systemic analgesics. Significant advantages are conferred on a postoperative patient; analgesia is provided with a minimal narcotic effect, less central sedation occurs and pulmonary function is improved. Multiple side effects are known to occur, however, the most significant being possible respiratory depression. Monitoring of respiration for at least 24 hours following intraspinal narcotic administration, on an acute basis, is thus required.

Chronic pain syndromes have been treated in the same fashion; analgesia is unaccompanied by significant changes in motor function, sympathetic outflow or re-

sponse to nonnoxious stimuli and apparently the risk of respiratory depression is very low. Patients with various malignant conditions have benefited from this technique.

Implantable devices designed to deliver the narcotics have been used; tolerance to continuous intrathecal infusion of morphine, however, has been noted. The best candidates for this procedure appear to be those patients with intractable pain below the diaphragm of malignant origin. Patients should respond to a test dose of intrathecally given morphine with at least six hours of pain relief. An intraspinal morphine preparation has been approved by the Food and Drug Administration and implantable reservoirs for continuous infusions of morphine are available. In the future, selective spinal antinociception will expand to other spinal receptor populations as we move to an era characterized by the delivery of multiple selective spinal agonists and antagonists of the central nervous system.

JOHN A. KUSSKE, MD

REFERENCES

Greenberg HS, Taren J, Ensminger WD, et al: Benefit from and tolerance to continuous intrathecal infusion of morphine for intractable cancer pain. J Neurosurg 1982 Sep; 57:360-364

Gustafsson LL, Schildt B, Jacobsen K, et al: Adverse effects of extradural and intrathecal opiates: Report of a nationwide survey in Sweden. Br J Anaesth 1982 May; 54:479-486

Onofrio BM, Yaksh TL, Arnold PG: Continuous low-dose intrathecal morphine administration in the treatment of chronic pain of malignant origin. Mayo Clin Proc 1981 Aug; 56:516-520

Yaksh TL: Spinal opiate analgesia: Characteristics and principles of action. Pain 1981 Dec; 11:293-346

When Should Intracranial Pressure Monitoring Be Used?

INTRACRANIAL PRESSURE MONITORING remains controversial and is not used consistently by neurosurgeons. Despite lack of actual proof of improved outcome due solely to intracranial pressure control, intracranial pressure monitoring nonetheless has strong advocates who cite anecdotal evidence for the importance of these techniques in some disease states.

Intracranial hypertension (usually defined as a pressure of 20 or 25 mm of mercury or more) has been shown repeatedly to correlate adversely with poor outcome from head injury. Most patients with traumatic coma and hemorrhagic abnormalities on computed tomographic (CT) scans have intracranial pressure elevations, which should be monitored and controlled if possible. In such comatose patients with normal initial findings on CT scans, intracranial hypertension rarely develops within 24 hours of injury but delayed CT abnormalities can develop and intracranial pressure can rise after the first day. Thus pressure monitoring should be considered for patients who remain comatose and whose CT scan findings become abnormal.

Neurologic dysfunction in Reye's syndrome, once thought to be almost uniformly fatal, usually is attended by increased intracranial pressure. While some permanent neurologic damage or even death can still occur with this toxic hepatoencephalopathy, brain injury probably arises from ischemia due to intracranial hypertension and often can be avoided by intracranial pressure monitoring and control.

In recent years monitoring of intracranial pressure has been used in a variety of neurosurgical patients. For patients undergoing craniotomy for lesions such as arteriovenous malformations, aneurysms or brain tumors in which the surgeon feels postoperative brain swelling may occur, intracranial pressure monitoring offers an important guide to therapy directed at ensuring optimal cerebral perfusion. Ventriculomegaly from cerebrospinal fluid outflow obstruction by hemorrhage or tumor can be treated by ventriculostomy and drainage; intracranial pressure monitoring via an intraventricular catheter can determine the amount of drainage required as well as resolving need for drainage. Permanent cerebrospinal fluid shunting can be avoided by this technique in some patients.

Iatrogenic barbiturate coma has been advocated in some types of brain injury such as trauma or focal ischemia, though the efficacy of this therapy is not yet proved. Because most neurologic function is severely depressed with this treatment, intracranial pressure monitoring is advocated to ensure that a progressive intracranial pathologic condition such as brain swelling or hematoma formation is detected and treated so that adequate cerebral perfusion is maintained.

The treatment of increased intracranial pressure has been discussed in detail elsewhere. Because there is some toxicity involved with these therapies, they should be used as sparingly as possible to maintain normal intracranial pressure. There is poor correlation with changes in the intracranial pressure and alterations in the neurologic state; intracranial pressure elevations can be detected earliest and best by pressure monitoring. Using current low-risk techniques for monitoring intracranial pressure, proper therapy in appropriate amounts can be administered to ensure adequate brain perfusion.

LAWRENCE H. PITTS, MD

REFERENCES

Kishore PRS, Lipper MH, Becker DP, et al: Significance of CT in head injury: Correlation with intracranial pressure. AJNR 1981 Jul/Aug; 2:307-311

Pitts LH, Martin N: Head injuries. Surg Clin North Am 1982 Feb; 62:47-60

Trauner DA, Brown F, Ganz E, et al: Treatment of elevated intracranial pressure in Reye syndrome. Ann Neurol 1978 Sep; 4:275-278

Computed Tomographic Guided Stereotaxis of the Brain

COMPUTED TOMOGRAPHIC (CT) imaging has enhanced the accuracy and safety of diagnosis and therapy in many provinces of medicine. The wedding of principles of stereotaxic neurosurgery and computed tomographic imaging has added an immediate new dimension to neurologic surgery and offers great potential for future innovation.

As opposed to CT-monitored techniques that commonly aid intracranial manipulation in the setting of a radiology suite, CT-guided stereotaxis allows selection of intracranial target points in a scanner, with minimal scan time (15 minutes or less). Target point data are